Preprints.org

Article

Study on the Sustainability of Farmers' Livelihoods Capital and its Impact on the Rural-urban Income Gap

Yuping Wu , Yuhuan Wu [*] , Haisong Wang [*] , Ning ZHu

Article

Study on the Sustainability of Farmers' Livelihoods Capital and its Impact on the Rural-urban Income Gap

Yuping Wu [1],[†], Yuhuan Wu [2],[†],[*] , Haisong Wang [2],[†],[*] and Ning Zhu [3]

[1] School of Public Administration and Policy, Renmin University of China, Beijing, 100872, China
[2] Department of Economics and Trade, Hebei University of Water Resources and Electric Engineering, Hebei,061000, China
[3] Institute of Agricultural Economics and Development, Chinese Academy of Agricultural Sciences, Beijing, 100081,China
[*] Correspondence: wuyuhuan@hbwe.edu.cn (Y.W.); micromoon@hbwe.edu.cn (H.W.)
[†] These authors contributed equally to this work.

Abstract: The concept and practice of 'livelihood' has undergone various stages in the development of Western countries. Its core has always focused on eradicating rural poverty and promoting rural development. This study utilizes the entropy value method to measure the comprehensive development level of the livelihood sustainability of farm households. Additionally, the Theil index is used to measure the presentation income gap, and multiple linear regression is utilized to test the impact of the livelihood capital sustainability of farm households on the presentation income gap. Results showed that the the sustainability of farm households' livelihood capital has a significant negative impact on the urban-rural income gap. In other words, improving the livelihood capital of farm households can significantly reduce the urban-rural income gap. Accordingly, it is proposed that efforts be made to enhance the sustainability of farm households' livelihoods, and to increase the contribution of the sustainable enhancement of farm households' livelihood capital to narrowing the rural-urban income gap.

Keywords: livelihood capital; rural-urban income gap; sustainable development

1. Introduction

Farm households serve as the fundamental unit of rural production, and the sustainability of their livelihood capital is critical to the success of rural development. Farm household livelihood capital refers to the resources and capabilities accumulated by farm households in the production, social, and natural environments. These include physical assets, natural resources, social capital, human capital, and financial capital[1]. The sustainability of these capitals is directly related to the livelihood security of farm households and social stability. Evaluating the sustainability of rural households' livelihood capital can aid in comprehending the current situation and issues of rural development. This can provide a scientific basis for formulating effective rural development policies.

As a result of climate change and evolving production methodologies, developing countries and regions, especially those with serious development difficulties, will face even greater difficulties in resolving farmers' sustainable livelihoods and embarking on an equitable development path.China is a large country with a significant population and a thriving agricultural sector[2,3]. The 'three rural issues' are crucial concerns that have a significant impact on the national economy and people's livelihoods. Since 2020, a series of high-level meetings and policy initiatives have outlined the central leadership's approach to governance. The rapid urbanization and industrialization in China have significantly altered the livelihoods of many rural areas, impacting traditional ways of life.

Since 1978, China has experienced rapid economic development, leading to a continuous improvement in the living standards of its residents. From 1978 to 2023, the per capital disposable income of urban residents increased from 343 yuan to 51,821 yuan, with an average annual growth rate of 11%. The per capita disposable income of rural residents increased from 134 yuan to 21,691

yuan, with an average annual growth rate of 11.97%. Additionally, China's urban-rural income gap decreased lightly from 2.56:1 to 2.39:1. Although the income level of both urban and rural residents has been increasing, there has always been an income gap between these two areas. This phenomenon has become a prominent manifestation of the multiple contradictions under China's dual economic structure[4–14]. In terms of the absolute income gap, the difference between urban and rural residents' income was only 209 yuan in 1978. However, by 2023, this gap increased to 30,130 yuan. Additionally, urban residents have access to education, housing, medical care, and public consumer goods, while the income of rural residents consists of a portion of gains in kind, as well as inputs of means of production for the expansion of production in the following year[15–18]. When considering all of these factors, the actual income gap is even greater than it appears.

Research has highlighted the significance of peasant household livelihood capital. However, less attention has been given to its sustainability.Rural livelihood research has matured and improved over time. Many scholars use the sustainability framework developed by the United Kingdom Department for International Development (DFID) to measure the livelihood capital of farm households and discuss the factors that affect its sustainability.

The sustainability of farm household livelihoods is influenced by various factors. In 1986, the German sociologist Ulrich Beck introduced the concept of risk society[19–22]. He defines risk as a systematic approach to addressing the hazards and uncertainties brought about by modernization itself. Drawing on sustainable livelihood theory, the author posits that risk factors impacting farmers' livelihoods can lead to depletion of their human, natural, physical, financial, and social capital, thereby exposing them to shared risks from both individual and external sources in their daily production and life. Additionally, scholars have examined the effects of climate change and emergencies on the livelihoods of farm households. Moreover, research has demonstrated that small-scale irrigation infrastructure and resources play a crucial role in sustaining farmers' livelihoods by influencing their participation decisions and outcomes.

Research on the urban-rural income gap focuses on measuring the gap and identifying its influencing factors. Ding, X(2023) studied the impact of institutional performance and government policies on the rural-urban income gap. Additionally, improving rural education levels is considered an important factor in reducing the urban-rural gap[23–26]. Government policies are aimed at reducing this gap and increasing farmers' income. The impact of urbanization on the income gap between urban and rural areas is significant. The sustainability of farmers' livelihood capital is crucial in addressing the rural-urban income gap, particularly in the context of rural poverty alleviation and economic development. For instance, in southern Shaanxi,China, Fang Su et al. (2021) conducted a study to determine the effective mechanisms of government poverty alleviation measures based on the sustainability of farmers' livelihoods. The study highlighted the significance of comprehending how livelihood capital endowment affects poverty alleviation and income growth under different conditions. Furthermore, research has focused on the impact of livelihood capital on sustainable income growth and agricultural development in the context of narrowing the urban-rural income gap[27–30]. In summary, the sustainability of farmers' livelihood capital is crucial in addressing the urban-rural income gap and promoting rural economic development. Factors such as education, infrastructure, government policies, and institutional performance significantly impact the sustainability of farmers' livelihoods and, consequently, the rural-urban income gap.

In summary, numerous studies exist on the sustainable development of farmers' livelihoods and the factors that influence it. However, these studies primarily focus on the impact of natural, human, or social capital on the sustainability of farmers' livelihoods. There are fewer empirical tests on the impact of farmers' livelihood sustainability on the urban-rural income gap. The study assesses the sustainability of farm household livelihoods in five dimensions: natural capital, financial capital, human capital, physical capital, and social capital[31–33]. It also measures the impact of this sustainability on the urban-rural income gap and provides policy recommendations. The findings

can serve as a reference for other developing countries seeking to improve the sustainability of farm household livelihoods and balance urban and rural development.

The study contributes to the body of knowledge, influences public policy and has an economic and commercial impact. This research methodology, which combines theory and practice, helps to promote the translation of academic research results into practical applications, thus better serving socio-economic development. By providing an in-depth discussion of the sustainability of farmers' livelihood capital, this paper helps to understand how farmers can maintain or improve their livelihoods in the face of external shocks and changes, thereby providing a more solid theoretical basis for relevant policy formulation. Meanwhile, it contributes to a more comprehensive understanding of the formation mechanism and influencing factors of the urban-rural income gap, and provides new ideas and perspectives for narrowing the urban-rural income gap.The results of the study can provide a scientific basis for the government and relevant departments to formulate policies on rural development, poverty alleviation and rural-urban integration[34,35]. Through the assessment and impact analysis of the sustainability of the livelihood assets of farming households, policy makers can better identify rural development needs and bottlenecks and formulate more effective and sustainable policies.

The following section presents our Theoretical analysis, which is followed by Research Methodology and Data Sources,Results of the study. The final section is the Conclusions and recommendations, divided into two subsections, the first subsection introduces Conclusions and recommendations of the study, the second subsection conducts Implications for developing countries. (Figure 1) illustrates the research path of this article.
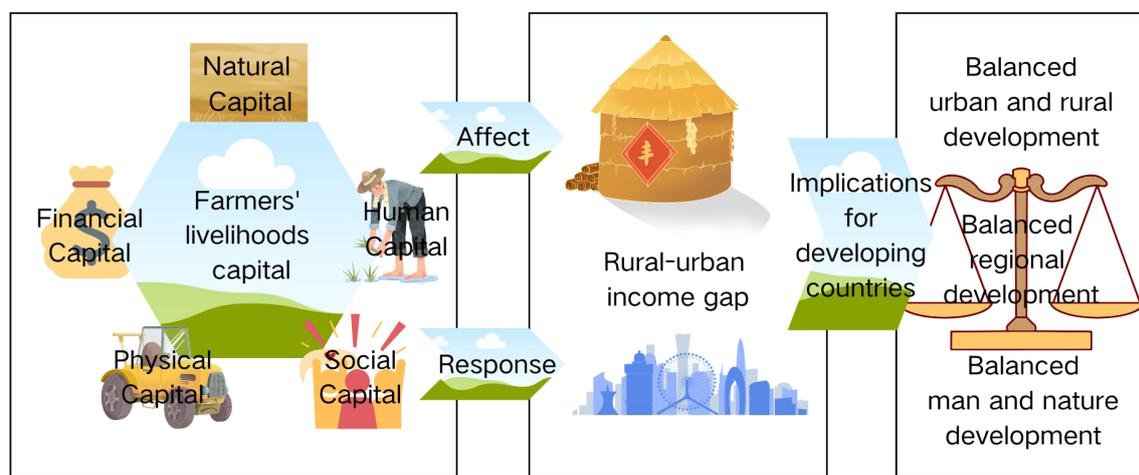
Figure 1. Technical route

2. Theoretical Foundations

2.1. Theory of Human Capital

The theory of human capital originated from William Petty's statement in 1662 that 'land is the mother of wealth, labor is the father of wealth. In The Wealth of Nations, published in 1776, Adam Smith analyzed the relationship between human capital and income. The modern theory of human capital developed rapidly in the 1950s and 1960s. According to Schultz.T.W (1960), the increase in productivity cannot be fully explained by resources, capital, and labor alone. Human capital is also

a crucial production factor. The level of human capital of a farm household has a significant impact on its income and poverty status. Higher levels of human capital increase the likelihood of earning a higher income. Farm households with insufficient human capital may become trapped in a difficult poverty cycle. Investing in human capital can increase income, but may cause a decline in income from physical capital and an increase in labor income, which can help reduce personal income inequality. Therefore, upgrading the human capital of farm households is an important means of achieving poverty reduction and sustainable livelihoods.

2.2. Theory of Urban-Rural Dual Economic Structure

Arthur Lewis developed the theory of dual urban-rural economic structure in 1954 in his article 'Economic Development under Conditions of Unlimited Supply of Labor. The theory proposes that developing countries typically have an economic structure where a modernized urban sector coexists with a traditional rural sector. This dual economic structure between urban and rural areas results in an unequal allocation of resources and a widening income gap. As labor is transferred, the economy develops gradually[36]. Labor becomes a scarce resource, while capital becomes abundant. Consequently, the return on labor increases, and the return on capital decreases. As a result, the income gap between the traditional agricultural sector and the modern industrial sector gradually narrows. As the process continues, the industrial structure changes and upgrades, the level of urbanization rises, the dual economy develops into a single economy, and the distribution of income gradually becomes more equal.

2.3. Theory of Income Redistribution

Income distribution theory examines how income is distributed among members of society and its impact on economic and social development. One key manifestation of unequal income distribution is the urban-rural income gap. To reduce this gap, it is important to consider the sustainability of the livelihood capital of farm households[37]. Welfare economics suggests that individual welfare is not only related to consumption and income levels, but also to the distribution of income in society. Therefore, maximizing social welfare requires not only maximizing individual income, but also ensuring a fair distribution of income in society. Italian economist Vilfredo Pareto (1906) introduced the concept of "'Pareto optimality", which links personal income distribution with social welfare. In 1920, Pigou advocated for state regulation of income distribution through tax policy and social expenditure to maximize social welfare34. Keynes argued that income distribution imbalances have a significant impact on overall consumption, which in turn affects aggregate demand and economic growth. He advocated for government measures to promote income distribution equality, such as raising the minimum wage, strengthening social welfare protection, and implementing progressive taxation policies. These measures would stimulate consumption and aggregate demand. These policy recommendations are crucial for mitigating the economic crisis and fostering stable economic growth.

2.4. Research Hypotheses

The following hypotheses are proposed in this study based on the above theoretical foundations:

Hypothesis 1 states that there is a significant difference in the sustainability of livelihood capital among farm households. Additionally, there are significant differences in the sustainability of farm household livelihood capital across regions due to variations in human capital[38]. For instance, farm households with higher levels of education generally possess higher cognitive abilities and skill levels, which enable them to adapt to market changes and seize livelihood opportunities.

Hypothesis 2 suggests that improving the sustainability of farm household livelihood capital can contribute to reducing the urban-rural income gap by increasing farmers' income.

Hypothesis 3 indicates that policy support and market environment significantly affect the sustainability of farm household livelihood capital. The government's policies and favorable

market conditions will improve the sustainability of farmers' livelihoods, promoting rural economic development and narrowing the urban-rural income gap.

3. Data and Methodology

3.1. Data

Data of livelihood capital measurement indicators and Income of urban and rural residents are from the National Bureau of Statistics of China.While the assessment of livelihood capital focuses on the resources that farmers currently possess and their ability to use these resources, inflation is a macroeconomic phenomenon whose effects are relatively complex and difficult to quantify accurately. For this reason, the assessment of livelihood capital in this paper focuses on direct observation and assessment of specific resources.

3.2. Entropy Method

The entropy method is a technique for determining the overall level of a system based on the degree of discreteness. Its basic principle involves assessing the weights of indicators by analyzing their relative changes as a whole. This allows for an accurate evaluation of the overall level. The basic steps of the entropy method are as follows:

(1) To eliminate the impact of differences in scale or order of magnitude on the evaluation results, it is necessary to standardize the indicators, given that there are variations in their scale and order of magnitude.

$$x'_{ij} = \frac{x_j - x_{min}}{x_{max} - x_{min}} \tag{1}$$

$$x'_{ij} = \frac{x_{max} - x_j}{x_{max} - x_{min}} \tag{2}$$

Equation (1) is a positive indicator and Equation (2) is a negative indicator.
Where
X_j is the value of indicator j
X_{max} is the maximum value of indicator i
X_{min} is the minimum value of indicator i
x'_{ij} is a standardized value
(2) Calculation of the weight of indicator j in the value of the indicator in year i.

$$y_{ij} = \frac{x'_{ij}}{\sum_{i=1}^{m} x'_{ij}} (0 \leq y_{ij} \leq 1) \tag{3}$$

where
i is 1,2,…,n
j is 1,2,…,m
(3) Calculate the information entropy value for the j indicator.

$$e_j = -K \sum_{i=1}^{m} y_{ij} \ln y_{ij} \tag{4}$$

where
K is a constant,$K = \frac{1}{\ln m}$
Assuming a value of d_j for the information utility, and $d_j = 1 - e_j$.The weight of the j

indicator is:

$$\mathbf{w_j} = \frac{d_j}{\Sigma_{i=1}^{m} d_j} \tag{5}$$

(4) Calculate the composite evaluation score of the sample using the following formula:

$$U = \sum_{i=1}^{n} y_{ij} \cdot w_j \times 100\% \tag{6}$$

Based on the research of scholars such as Zhang Chenjia (2020), this paper measures the sustainability level of farmers' livelihood capital by selecting 17 indicators such as total sown area of crops, total water resources and other indicators from five dimensions, namely natural capital, financial capital, human capital, physical capital and social capital (as shown in Table 1). Table 2 shows the average values of the indicators selected by the entropy method for the years 2008-2022.

Table 1. Livelihood capital measurement indicators.

Dimension	Indicator(Units)	Code	Nature of the Indicator
Natural Capital	Total area of crops sown (thousands of hectares)	a1	Positive
	Total water resources (billion cubic meters)	a2	Positive
	Area of orchards (thousands of hectares)	a3	Positive
	Poultry egg production (million tons)	a4	Positive
	Milk production (million tons)	a5	Positive
	Meat production (million tons)	a6	Positive
Financial Capital	Employment in urban units in the financial sector (ten thousand persons)	b1	Positive
	Per capita disposable income of rural residents (Yuan)	b2	Positive
	Value added of agriculture, forestry, animal husbandry and fisheries (billion yuan)	b3	Positive
Human Capital	Employed persons in urban units of agriculture, forestry, animal husbandry and fisheries (ten thousand persons)	c1	Positive
	Number of graduates of general higher education institutions (ten thousand persons)	c2	Positive
Physical Capital	Total retail sales of consumer goods (billions of yuan)	d1	Positive
	Total power of agricultural machinery (ten thousand kilowatts)	d2	Positive
	Road mileage (ten thousand kilometers)	d3	Positive
Social Capital	Expenditures on agriculture, forestry and water affairs in local finances (billions of yuan)	e1	Positive
	Number of healthcare institutions	e2	Positive
	Urbanization rate(%)	e3	Positive

Table 2. Average value of indicators.

Year	a1	a2	a3	a4	a5	a6	b1	b2	b3	c1	c2	d1	d2	d3	e1	e2	e3
2008	5018.24	884.98	329.70	87.17	114.70	234.80	13.47	5208.77	1068.41	13.22	16.51	3704.19	2651.30	12.03	136.63	8978.61	0.48
2009	5072.34	780.01	337.24	88.47	113.51	246.76	14.49	5652.81	1116.64	12.06	17.13	4279.95	2822.45	12.45	206.51	29566.81	0.49
2010	5115.47	996.97	344.55	89.12	115.34	255.67	15.16	6502.42	1276.11	12.11	18.56	5097.02	2992.92	12.93	249.73	30223.45	0.51
2011	5172.92	750.28	348.65	90.69	118.00	256.94	16.29	7688.84	1485.11	11.60	19.62	6038.89	3152.73	13.25	307.13	30786.74	0.52
2012	5228.10	952.48	354.51	92.30	120.76	270.56	17.03	8734.84	1628.42	10.92	20.15	6917.18	3308.35	13.67	370.04	30654.74	0.53
2013	5280.72	901.86	356.24	92.78	113.92	275.32	17.35	9810.71	1760.92	9.50	20.60	7833.64	3351.83	14.05	413.63	31432.19	0.54
2014	5328.49	879.57	374.44	93.35	120.15	280.86	18.27	10904.23	1854.03	9.18	21.27	8770.85	3485.70	14.40	439.81	31659.10	0.55
2015	5381.59	902.02	361.68	96.75	121.12	278.23	19.58	11876.84	1930.63	8.71	21.96	9244.77	3604.13	14.77	536.83	31726.71	0.57
2016	5385.13	1047.30	352.15	99.83	116.20	275.41	21.45	12877.71	2015.29	8.49	22.71	10187.30	3136.95	15.15	574.46	31722.39	0.58
2017	5365.55	927.77	359.63	99.88	98.02	279.17	22.22	13999.58	2085.76	8.24	23.74	11204.08	3186.56	15.40	592.91	31827.39	0.59
2018	5351.69	885.90	395.83	100.91	99.18	278.21	22.55	15228.26	2179.30	6.21	24.30	12186.56	3237.80	15.63	661.07	32175.26	0.60
2019	5352.60	936.81	396.02	106.74	103.27	250.28	26.65	16678.06	2373.45	4.33	24.47	13161.85	3314.78	16.17	720.34	32502.55	0.61
2020	5402.81	1019.53	407.94	111.86	110.97	249.95	27.71	17814.26	2625.70	2.77	25.72	12640.00	3407.17	16.77	756.29	32997.48	0.64
2021	5441.78	956.07	413.16	109.96	118.80	290.00	26.41	19698.52	2804.96	2.79	26.66	14216.85	3476.27	17.03	694.70	33255.97	0.65

3.3. Theil Index

In 1967, Thiel examined inequality through the concepts of information quantity and entropy. Let μ be the probability of the occurrence of event A, where $P(A) = \mu$. The information quantity of the known occurrence of this event is set to $h(\mu)$, which is a decreasing function of μ, $h(\mu) = \log(1/\mu)$ .With n events, where the probability of occurrence of each is $u_1, u_2, \dots, u_n$,the expected information quantity (also known as entropy) is $H(u) = \sum_{i=1}^{n} u_i \log(1/u_i)$ .The closer thc value of u_i is to $1/n$,the greater the entropy will be. If we consider u_i as the income share of the i income unit,

then $H(u)$ reflects the degree of inequality in income differences. The larger $H(u)$, the more equal the income distribution. If absolute equality, where all income units are equal to $1/n$, then $H(u)$ takes the maximum value log(n).Thiel defines $\log(n) - H(u)$ as an indicator of inequality.

The Theil index expresses the level of income disparity between urban and rural areas as a weighted sum of the logarithm of the ratio of income share to population share in each province and municipality. The weights are determined by the share of income in each province and municipality [**?**].

$$Theil_t = \sum_{i=1}^{2} \left(\frac{I_{it}}{I_t} \right) \ln \frac{I_{it}/I_t}{N_{it}/N_t} = \left(\frac{I_{1t}}{I_t} \right) \ln \frac{I_{1t}/I_t}{N_{1t}/N_t} + \left(\frac{I_{2t}}{I_t} \right) \ln \frac{I_{2t}/I_t}{N_{2t}/N_t} \tag{7}$$

If the Theil index is 0, it means that there is no difference between the subgroups, i.e., perfect equality; conversely, if the Theil index is larger, it means that the difference is larger and the degree of inequality is higher.

4. Results

4.1. Sustainability of Farmers' Livelihoods

(Figure 2) displays the weight coefficients of the selected indicators calculated by the entropy method. As shown in the figure, natural capital accounts for the largest proportion, while human capital and physical capital rank second and third, respectively. Therefore, it can be concluded that the primary factors influencing the sustainability of farmers' livelihood capital are natural capital, human capital, and physical capital. Therefore, to enhance the sustainability of farmers' livelihood capital, it is necessary to implement comprehensive measures. On one hand, it is necessary to enhance the protection and management of natural resources to achieve the sustainable use of natural capital. On the other hand, it is necessary to increase investment in education, healthcare, and other fields to improve the human capital of farmers. Additionally, it is important to strengthen infrastructure development to improve the production and living conditions of farmers and promote the accumulation of physical capital. Furthermore, it is essential to consider the selection of livelihood strategies for farm households. Various livelihood strategies depend on different levels of livelihood capital, thus it is crucial to assist farmers in choosing appropriate livelihood strategies based on the specific local conditions. For instance, in regions abundant in natural resources, farmers can be incentivized to engage in eco-agriculture, specialty planting, and other related industries. Similarly, in areas rich in human resources, rural labor export can be promoted, and rural tourism and other industries can be developed.
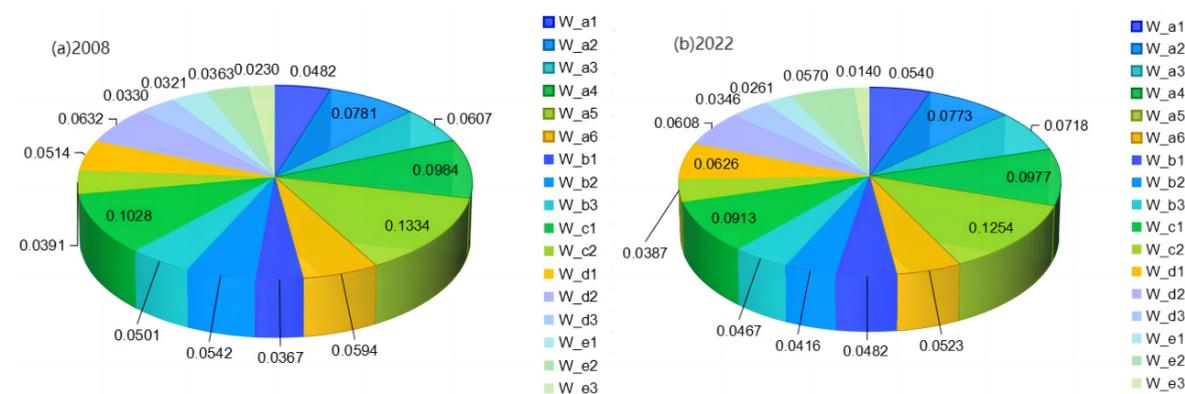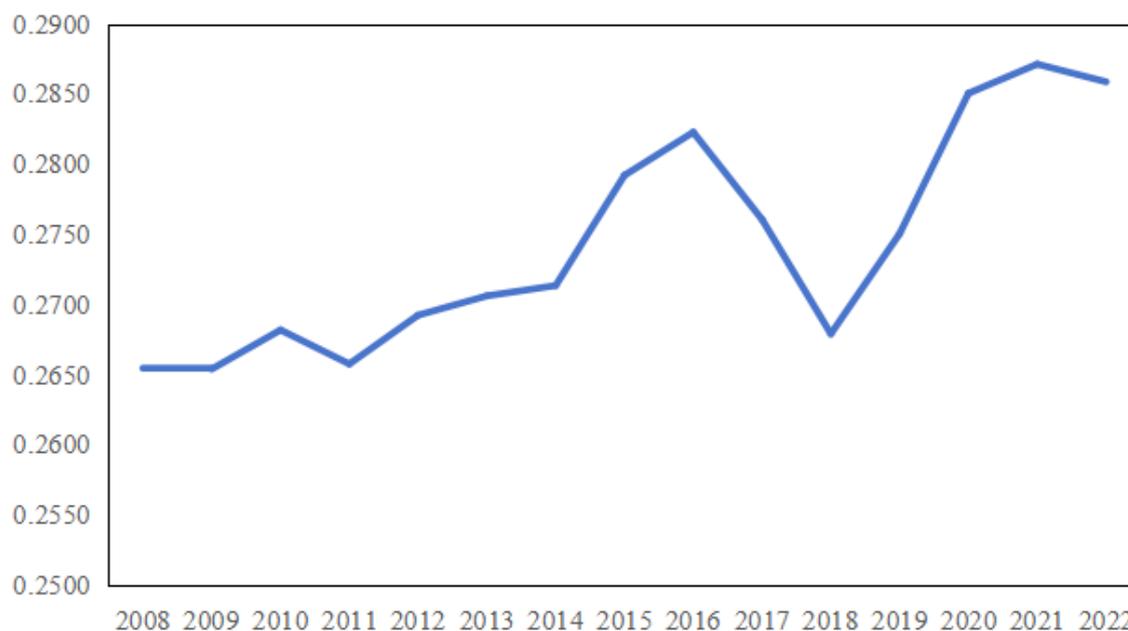

Figure 2. Weighting coefficients for each indicators

According to (Figure 3) , the level of sustainable integrated development of farm household livelihoods (mean) can be categorized into three phases: the first phase is a steady increase from 2008-2016, followed by a sharp decline from 2016-2018,and a rebound in the period 2018-2022.

Figure 3. Level of sustainable integrated development of farm household livelihoods

During the period from 2008 to 2016, the sustainable integrated development of farm households' livelihoods showed a steady increase. This trend can be attributed to the government's increased support for rural areas, which has boosted the development of the rural economy and the income of farm households. Positive progress has been made in infrastructure development, improvement of the social security system, and environmental protection in rural areas. These efforts have created favorable conditions for the sustainable development of farm households.

From 2016 to 2018, the second phase saw a significant decline in the level of sustainable integrated development of livelihoods of farm households. This decline may be attributed to a combination of factors, including market fluctuations,natural disasters, and policy adjustments. As a result, the economic income and quality of life of farm households decreased,which in turn affected their capacity for sustainable development.

During the third phase, which spans from 2018 to 2022, the sustainable integrated development of farm households' livelihoods gradually rebounds. This may be attributed to the government's renewed support for rural areas through a series of policies that have contributed to the recovery and development of the rural economy. Farm households have adjusted their livelihood strategies and sought new development opportunities to improve their sustainable development capacity.

(Figure 4) displays the composite score of livelihood sustainability of farm households measured using the entropy method. (Figure 4) displays the regional distribution of the comprehensive score of farm household livelihood sustainability in each province of China for the years 2008, 2011, 2014, 2017, 2020, and 2022.

As can be seen in(Figure 4), the livelihood sustainability of farm households shows significant regional differences, mainly due to:

First, there are geographical differences. China's geography is diverse, with variations in climate, land resources, and water resources across different regions. In some areas, crop cultivation and breeding are more successful, leading to higher sustainability of farmers' livelihoods. However, in

other areas, agricultural production faces greater challenges due to poor natural conditions, resulting in lower sustainability of farmers' livelihoods.

Second, there are differences in economic development. The eastern and coastal areas are relatively more economically developed, with a higher degree of agricultural modernization, better sales channels for agricultural products, and relatively higher incomes for farmers. On the other hand, the western and rural areas are relatively economically backward, making it difficult to sell agricultural products and resulting in lower incomes for farmers.

Third, there are differences in government policy support for agricultural development in different areas. Some local governments have provided greater attention and support to agricultural development by offering more agricultural subsidies and support policies, which promote the sustainability of farmers' livelihoods. In contrast, certain local governments do not provide adequate support for agriculture, resulting in greater difficulties and lower sustainability for farmers.

Additionally, differences in education and technology levels have a significant impact on the modernization of agricultural production and livelihood sustainability. In areas with higher levels of education, farmers receive more agricultural technology training and information, resulting in more advanced agricultural production and higher livelihood sustainability. However,in areas with lower levels of education, farmers lack access to advanced agricultural technology and information, resulting in lower livelihood sustainability. It is important to note that socio-cultural factors may also play a role. Different regions have varying socio-cultural contexts that can impact how farmers earn a living and achieve sustainable livelihoods. For instance,some regions prioritize traditional agriculture, while others prioritize modern agriculture or non-farming industries.
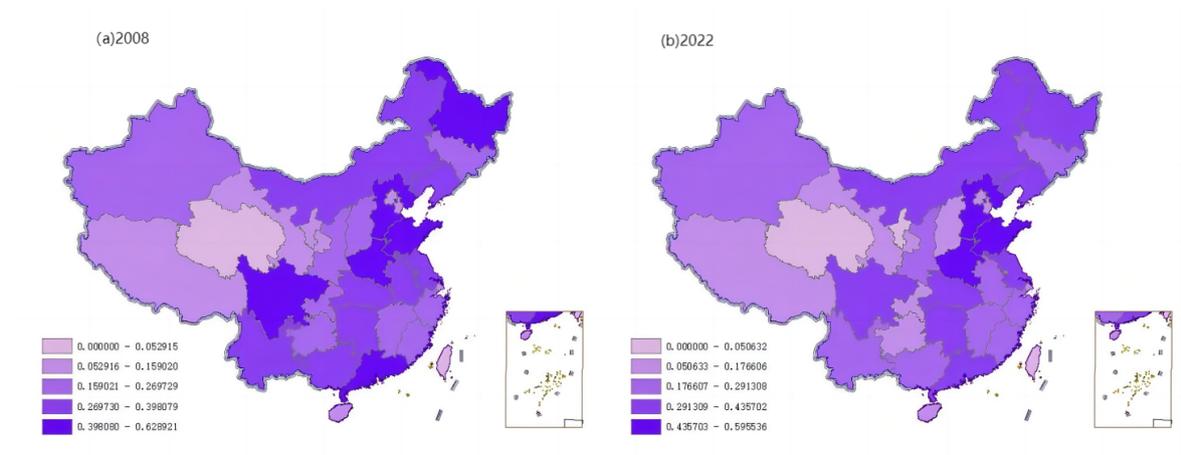
Figure 4. Level of sustainable integrated development of farmers' livelihoods

4.2. Urban-rural income gap

(Figure 5) displays the regional distribution of the income gap between urban and rural residents in China's provinces, as measured by the Theil Index. In 2010, the State adopted four measures to reform the income distribution system: increasing farmers' income, supporting low-income groups, raising employee wage income, and regulating personal income. In 2011,the State established the new national poverty alleviation standard for farmers' per capital net income at 2,300 yuan, which was a 92% increase compared to 2009. The national poverty alleviation standard for the central financial institutions was also established. In 2011, the State established a new national standard for poverty alleviation, setting the per capital net income for farmers at 2,300 yuan. This was a 92% increase compared to 2009. Additionally, the central financial authorities provided 22 billion yuan in subsidies for good seeds, which played a crucial role in increasing farmers' incomes.
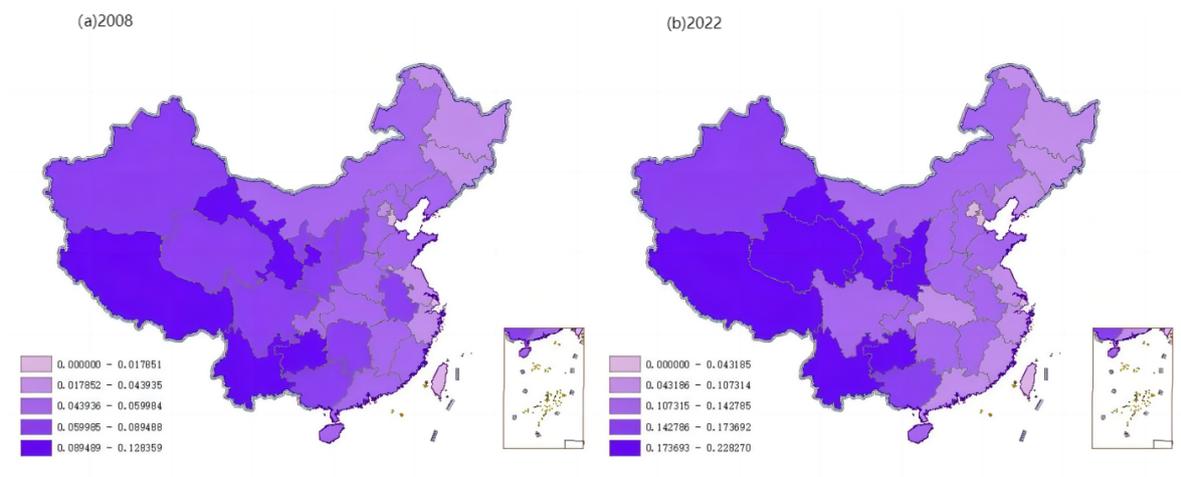
Figure 5. Regional distribution of urban-rural income gap

China's reform and opening-up policy has prioritized the development of resources in the eastern coastal areas due to geographic conditions. As the reform and opening-up process continues, China has also implemented policies to support the development of the central and western regions, including the rise of the central region and the development of the western part of the country. Due to ongoing development, a pattern has emerged where eastern China leads in development, central China accelerates its rise, and western China catches up.

The urban-rural income gap is relatively small in the eastern region with a higher level of economic development, while the western region with less developed economic development is more likely to have a widening urban-rural income gap. This finding is consistent with the research of scholars such as Wang Xiaoqing (2013), Jiang Yuekun, and Shi Pengjuan (2024). The reasons for this phenomenon are:

First, regions with a high level of economic development usually have more complete infrastructure, educational resources and public services such as health care, which are conducive to improving the living standards and income levels of rural residents, thus reducing the urban-rural income gap. Less developed regions often lack the conditions necessary for rural residents to obtain the same development opportunities and treatment as urban residents, leading to a widening of the urban-rural income gap.

Second, regions with a high level of economic development often have a more diversified industrial structure and develop-ment model, which can provide rural residents with more employment opportunities and ways to increase their income. In less developed areas, the industrial structure is relatively simple, and rural residents can only engage in traditional agricultural production, which limits their sources of income and makes it difficult to match the income level of urban residents.

Additionally, the government's policy orientation and support efforts also have a significant impact on the urban-rural income gap. In regions with greater economic development, governments may prioritize coordinated development between urban and rural areas and implement supportive policies to promote rural economic growth and increase residents' income. In less developed regions, the government may face more financial pressures and development problems, making it difficult to fully address the development needs of rural areas. This can lead to a widening of the urban-rural income gap.

To solve this phenomenon, we can take a series of measures to promote the coordinated development of urban and rural areas and narrow the income gap between urban and rural areas. First, the government should increase support for rural areas, improve infrastructure and public services in rural areas, and create better development conditions for rural residents. Second, it should promote industrial restructuring, transformation and upgrading in rural areas, and guide rural residents to shift to high value-added industries to broaden their income sources. Additionally, it is important

to strengthen exchanges and cooperation between urban and rural areas to facilitate the sharing of resources and complementary advantages, ultimately achieving common prosperity for both urban and rural areas.

4.3. Farm Household Livelihood Capital Sustainability and Its Impact on Rural-Urban Income Gap

(1) Model Setting

Multivariate linear regression is used to measure the impact of sustainable livelihoods of farm households on the urban-rural income gap. The function is constructed as follows:

$$T_{it} = f(SUS_{it}, \quad AVGDP_{it}, \quad CFD_{it}, \quad STR_{it}, \quad IIM_{it}) \tag{8}$$

imports to GDP,

where

T_{it} is the Theil index reflecting the urban-rural income gap, SUS_{it} is the level of sustainable livelihood development of farm households, $AVGDP_{it}$ is GDP per capita, reflecting the level of economic development, CFD_{it} is the level of foreign trade development, which is Total amount of imports and exports at the location of the business unit and STR_{it} is the industrial structure, the share of the tertiary sector in GDP (ŏ), IIM_{it} is the share oftechnology market tumover, *i* is the regional identification, indicating the provinces, *t* is the time, spanning from 2008 to 2022. The indicators were logarithmized to eliminate heteroskedasticity, based on the functional relationship between openness to the outside world and the income gap between urban and rural areas.

$$T_{it} = c_{it} + \beta_{i1}SUS_{it} + \beta_{i2}\text{In}AVGDP_{it} + \beta_{i3}\text{In}CFD_{it} + \beta_{i4}STR_{it} + \beta_{i5}\text{In}IIM_{it} + \varepsilon_{it} \tag{9}$$

(2) Results Analysis Model 1 shows the results of the regression with only the sustainability of farm household livelihoods as the independent variable, and Model 2 shows the results of the regression with five independent variables (as shown in Table 3). According to the results of the multiple linear regression, the sustainable development of farm household livelihoods can significantly reduce the urban-rural income gap. At the same time. The reasons for this are as follows:

First, the sustainability of farm household livelihood capital implies that the economic vitality and development capacity of rural areas have been enhanced. This includes the sustainable use and development of farmers' natural capital , physical capital , financial capital, human capital , and social capital. Effective management and value addition of these capitals can improve the income level and quality of life of farm households, narrowing the urban-rural income gap.

Second, the enhancement of the sustainability of farmers' livelihood capital will help promote the upgrading of the industrial structure and the transformation of the economic development mode in rural areas. The accumulation and enhancement of farmers' livelihood capital will lead to the gradual development of the industrial structure in rural areas towards higher value-added, more environmentally friendly, and sustainable practices. This will improve the economic competitiveness of rural areas, attract more investment and employment opportunities, further promote rural economic development, and narrow the income gap between urban and rural areas.

Finally, the improved sustainability of farmers' livelihood capital will also help raise the overall welfare level of rural areas. When the livelihood capital of farm households is safeguarded and developed, their needs for public services such as education, medical care, and social security will also be satisfied. This will help raise the overall welfare level of rural areas, narrow the gap between urban and rural areas in terms of public services, and further reduce the income gap between urban and rural areas.

Four variables, namely GDP per capita, the ratio of total imports and exports to GDP, the share of the tertiary industry in GDP, and the share of technology market transactions, were added to the regression model, and the results of Model 2 were obtained. The regression results of Model 2 indicate that the sustainability of farmers' livelihood capital continues to have a significant negative

impact on the income gap. Additionally, the level of regional economic development and foreign trade development, as well as the industrial structure, have a significant positive impact on the urban-rural income gap. However, the share of technology market transactions does not have a significant impact.

In summary, enhancing the sustainability of farmers' livelihood capital is crucial in narrowing the urban-rural income gap. The government can achieve this by investing more in rural areas, improving infrastructure, promoting agricultural product exports and foreign economic cooperation, guiding and supporting industrial structure adjustments, and promoting the transformation and modernization of traditional agriculture to eco-agriculture. These measures will help achieve the goal of coordinated development of urban and rural economies and common prosperity.

Table 3. Results of farmers' livelihood capital sustainability and its impact on urban-rural income gap.

	Model 1				Model 2		
Variable	Coefficient	Std. Error	t-Statistic	Variable	Coefficient	Std. Error	t-Statistic
X1?	-0.2677***	0.0282	-9.4934	X1?	-0.1464 ***	0.0294	-4.9808
X2?	——	——	——	X2?	0.0793***	0.0187	4.2426
X3?	——	——	——	X3?	-0.0346***	0.0068	-5.0781
X4?	——	——	——	X4?	-0.0035***	0.0014	-2.4921
X5?	——	——	——	X5?	-0.0001	0.0006	-0.0851
C	0.1679***	0.0077	21.6775	C	0.5284***	0.0672	7.8620
R-squared	0.9681	Mean dependent var	0.0944	R-squared	0.9749	Mean dependent var	0.0944
Adjusted R-squared	0.9646	S.D. dependent var	0.0450	Adjusted R-squared	0.9719	S.D. dependent var	0.0450
S.E. of regression	0.0085	Akaike info criterion	-6.6128	S.E. of regression	0.0075	Akaike info criterion	-6.8349
Sum squared resid	0.0300	Schwarz criterion	-6.2030	Sum squared resid	0.0236	Schwarz criterion	-6.3895
Log likelihood	1583.4740	Hannan-Quinn criter.	-6.4515	Log likelihood	1639.1090	Hannan-Quinn criter.	-6.6596
F-statistic	282.1260	Durbin-Watson stat	0.2204	F-statistic	328.2892	Durbin-Watson stat	0.2334
Prob(F-statistic)	0.0000			Prob(F-statistic)	0.0000		

***, **, * indicate significant at 1%, 5%, 10% level, respectively.

5. Discussion

5.1. The Unique Aspects and Contributions of This Study

(1)The study looks at the urban-rural income gap from a relatively novel perspective - the sustainability of farm households' livelihood capital. While traditional studies tend to focus on the impact of factors such as macroeconomic policies, allocation of educational resources and industrial structure on the urban-rural income gap, this study goes deeper to the farm household level and focuses on the role of farm households' own livelihood capital and its sustainability on the urban-rural income gap. This combination of micro and macro research perspectives provides a new entry point for understanding urban-rural development imbalances.

(2)The study emphasises the sustainability of livelihood capital, not just livelihood capital itself. This means that the study focuses not only on the resources that farm households currently possess, but also on whether these resources can be maintained and increased in the future. This focus on sustainability contributes to a more comprehensive assessment of the livelihood status of farm households and their ability to cope with external shocks and changes.

(3)The study not only analyses the direct impact of farm household livelihood capital on the rural-urban income gap, but can also explore the mechanisms and pathways behind this impact. For example, improving household livelihood capital may reduce the rural-urban income gap by promoting rural economic development and raising farmers' income levels. Such in-depth analyses of urban-rural interactions can help to better understand the dynamic process of urban-rural development.

5.2. Limitations of This Study

(1)The definition and measurement of livelihood capital may vary depending on the context, objectives and methodology of the study, which can lead to difficulties in comparing and interpreting results.There may be complex interactions between the different components of livelihood capital and these interactions may not have been adequately explored in the research.

(2)The study may not have adequately accounted for variability within different groups of farmers, e.g. farmers with different income levels and livelihood strategies may perceive and respond differently to the sustainability of livelihood assets and the urban-rural income gap.

(3)Both farm household assets and the rural-urban income gap are dynamic processes that may require a long period of observation and research to reveal their underlying patterns and trends. This study may be limited by time and may not adequately reflect these dynamic changes.Changes in the socio-economic environment and policies may have important impacts on the livelihood capital of farm households and the rural-urban income gap that may have occurred during the study period, but may not have been adequately considered and analysed.

6. Conclusions and Recommendations

This paper utilizes data from the National Bureau of Statistics between 2008 and 2022. The sustainability of the livelihood of farm households is measured using the entropy value method, while the urban-rural income gap is analyzed using the Theil index. Based on this analysis, the paper empirically examines the impact of the sustainability of the livelihood of farm households on the urban-rural income gap. The following conclusions are drawn: first, natural capital, human capital and physical capital are the main factors affecting the sustainability of farmers' livelihood capital; the overall level of farmers' livelihood capital sustainability shows a trend of increasing, then decreasing, then increasing. Second, the urban-rural income gap in China has declined significantly, but there are significant regional differences, with a relatively small urban-rural income gap in the eastern region with a higher level of economic development, and a relatively large income gap in the western region. Furthermore, enhancing farmers' livelihood capital can significantly reduce the urban-rural income gap. This is because the sustainability of farmers' livelihood capital has a significant negative impact on the urban-rural income gap.

The study's recommendations are as follows:

First, efforts should be made to enhance policy support for natural, human and physical capital. Land is the most important asset for farmers' livelihoods. Therefore, it is necessary to deepen the reform of the rural land system, clarify the land rights and interests of farmers, and safeguard their right to use, income, and transfer of land. Additionally, farmers should be encouraged to achieve large-scale and intensive land operations, improving land use efficiency through land transfer and joint-stock cooperation. To enhance the resilience of the agricultural sector, it is necessary to strengthen infrastructure construction, improve material capital support for farmers, and focus on enhancing the training of new farmers. Additionally, farmers' market awareness and risk management ability should be improved through training and education, so that they can better cope with external shocks. To enhance the overall development of rural areas, it is recommended to upgrade the level of rural education, strengthen the skills training of farmers, and guide them towards more efficient and environmentally friendly agricultural production methods. Additionally, increasing investment in rural infrastructure and public service facilities is necessary.

Second, it should strengthen policy stability and continuity, improve the sustainability of farmers' livelihoods, and narrow the income gap between urban and rural areas. To achieve this, it is important to ensure the long-term stability of rural development policies and minimize the impact of policy changes on the livelihoods of rural households. To reduce dependence on a single source of income and increase the diversity and sustainability of livelihoods, it is recommended to encourage the development of multiple business models and industries in rural areas. An effective monitoring mechanism should be established by the government to regularly assess trends in the urban-rural

income gap and ensure the relevance and effectiveness of policies. Increase investment in rural infrastructure, particularly in education, healthcare, and transportation, to reduce the disparity in basic public services between urban and rural areas. Promote integration of industry, markets, and society between urban and rural areas to overcome the urban-rural divide and achieve coordinated economic and social development.

Third, strengthen the accumulation and optimization of farmers' livelihood capital. To improve the knowledge and skills of farm households, education and training should be provided. Additionally, the physical capital of farm households should be strengthened by improving agricultural production conditions and increasing the level of agricultural mechanization. To provide necessary financial support, financial capital should be developed and more financial products and services should be made available to farm households. Finally, the social security system should be established and improved to reduce the financial burden of farm households caused by unforeseen factors such as diseases and disasters.

Fourth, we should promote integration between urban and rural areas and work towards narrowing the income gap. To improve rural industries and increase the value of agricultural products, encourage rural migrant workers to return to their hometowns and utilize their skills and experience to develop the rural economy. Additionally, improve rural infrastructure to enhance the quality of life and efficiency of rural residents. Finally, promote the flow of urban capital, technology, and talent to the countryside through policy guidance and incentives.

Furthermore, to promote policy and institutional innovation, it is recommended to formulate and implement fair tax and distribution policies. This will ensure that rural households receive a reasonable return on their labor and capital. Additionally, the land system should be reformed to safeguard the land-use rights of rural households and inspire them to invest in and protect their land. Finally, the rural financial system should be reformed to improve the convenience and accessibility of financial services for rural households.

References

1. Rocca J L .Ka-ho Mok, Social and Political Development in Post-Reform China[M].Macmillan Press ;,2000.
2. Zhou Q , Li Z .The impact of industrial structure upgrades on the urban–rural income gap: An empirical study based on China's provincial panel data[J].Growth and Change, 2021.DOI:10.1111/grow.12502.
3. Liu Y S .Urban-Rural Transformation Geography[J].Sustainable Development Goals Series, 2021.DOI:10.1007/978-981-16-4835-9.
4. Meng, H.; Deng, P.; Zhang, J. Nonlinear Impact of Circulation-Industry Intelligentization on the Urban–Rural Income Gap: Evidence from China. Sustainability 2022, 14, 9405. https://doi.org/10.3390/su14159405.
5. Zhang, P.; Li, W.; Zhao, K.; Zhao, S. Spatial Pattern and Driving Mechanism of Urban–Rural Income Gap in Gansu Province of China. Land 2021, 10, 1002. https://doi.org/10.3390/land10101002.

6. Junqing He, Kunhao Pan, Xiaoqun Dong, Zhuoyang Song, LiuYiBo LiuYiBo, Qianguosun Qianguosun, Yuxin Liang, Hao Wang, Enming Zhang, and Jiaxing Zhang. 2024. Never Lost in the Middle: Mastering Long-Context Question Answering with Position-Agnostic Decompositional Training. In Proceedings of the 62nd Annual Meeting of the Association for Computational Linguistics (Volume 1: Long Papers), pages 13628–13642, Bangkok, Thailand. Association for Computational Linguistics.

7. You, Heyuan. "Research Article Assessing Relationships between Peasant Household Livelihood Assets and Regional Agricultural Pollution in China Using Grey Correlation Analysis." Advance Journal of Food Science and Technology 9.6 (2015): 460-465.

8. Zhang, Zhuoyuan. Handbook of Chinese Economics. Springer Nature, 2023.

9. Zhao, X.; Liu, L. The Impact of Urbanization Level on Urban–Rural Income Gap in China Based on Spatial Econometric Model. Sustainability 2022, 14, 13795. https://doi.org/10.3390/su142113795.

10. Wang, C.; Zhou, Z.; Chen, Q.; Feng, Q.; Zhu, C. Study on the Livelihood Vulnerability of the Poor Relocated Households in Karst Area: A Case Study of Liupanshui Area. Agriculture 2022, 12, 1577. https://doi.org/10.3390/agriculture12101577.

11. Yang, H.; Huang, Z.; Fu, Z.; Dai, J.; Yang, Y.; Wang, W. Does Land Transfer Enhance the Sustainable Livelihood of Rural Households? Evidence from China. Agriculture 2023, 13, 1667. https://doi.org/10.3390/agriculture13091667.

12. Ren, J.; Lei, H.; Ren, H. Livelihood Capital, Ecological Cognition, and Farmers' Green Production Behavior. Sustainability 2022, 14, 16671. https://doi.org/10.3390/su142416671.

13. Su, F., Yin, Yj. Optimal livelihood strategy for different poverty groups among farmers: a case study of the Qin-Ba Mountain area in South-Shaanxi, China. J. Mt. Sci. 17, 1206–1220 (2020). https://doi.org/10.1007/s11629-019-5566-9.

14. J. Xu, Y. Hu and X. Zheng, "Karst rocky desertification and peasant household anti-poverty livelihood behaviors: Current situation and expectation," 2011 19th International Conference on Geoinformatics, Shanghai, China, 2011, pp. 1-5, doi: 10.1109/GeoInformatics.2011.5980842.

15. Ruiying Z , Jianchao X , Nan Z .The Research on Peasant Sustainable Livelihood Models in Rural Tourism Areas Under Urbanization — A Case from Jixian, Tianjin[J].Chinese Journal of Urban and Environmental Studies, 2015, 03(1):1550008.DOI:10.1142/S2345748115500086.

16. Agbley G K. Land grabbing and the gendered livelihood experience of smallholder farmers in Northern Ghana: Through a human development and capability lens[J]. Ghana Journal of Development Studies, 2019, 16(1): 155-180.

17. Wang C, He X, Song X, et al. Dynamic livelihood impacts of COVID-19 on different rural households in mountainous areas of China[J]. Plos one, 2022, 17(9): e0273816.

18. Hu Z, Song G, Hu Z, et al. How to promote the balanced development of urban and rural China? Evidences from reallocating idle rural residential land of Zhejiang province, China[J]. Plos one, 2023, 18(6): e0287820.

19. Chen L, Peng J, Zhang Y. Research on the Impact of Rural Land Transfer on Non-Farm Employment of Farm Households: Evidence from Hubei Province, China[J]. International Journal of Environmental Research and Public Health, 2022, 19(23): 15587.

20. Guo A, Wei Y, Zhong F, et al. How do climate change perception and value cognition affect farmers' sustainable livelihood capacity? An analysis based on an improved DFID sustainable livelihood framework[J]. Sustainable Production and Consumption, 2022, 33: 636-650.

21. Zhao X, Xiang H, Zhao F. Measurement and spatial differentiation of farmers' livelihood resilience under the COVID-19 epidemic outbreak in rural China[J]. Social Indicators Research, 2023, 166(2): 239-267.

22. Maru H, Haileslassie A, Zeleke T. Impacts of small-scale irrigation on farmers' livelihood: Evidence from the drought prone areas of upper Awash sub-basin, Ethiopia[J]. Heliyon, 2023, 9(5).

23. Ding, X.; Lu, Q.; Li, L.; Sarkar, A.; Li, H. Evaluating the Impact of Institutional Performance and Government Trust on Farmers' Subjective Well-Being: A Case of Urban–Rural Welfare Gap Perception and Family Economic Status in Shaanxi, Sichuan and Anhui, China. Int. J. Environ. Res. Public Health 2023, 20, 710. https://doi.org/10.3390/ijerph20010710.

24. Li, F., Liu, D., Gao, P. et al. Analysing how government-provided vocational skills training affects migrant workers' income: A study based on the Livelihood Capital Theory. Humanit Soc Sci Commun 11, 396 (2024). https://doi.org/10.1057/s41599-024-02919-4.

25. Zhao, X.; Liu, L. The Impact of Urbanization Level on Urban–Rural Income Gap in China Based on Spatial Econometric Model. Sustainability 2022, 14, 13795. https://doi.org/10.3390/su142113795.

26. Wen, S.; Xiao, Q.; Li, J.; Li, J. The Impact of Agricultural Insurance on Urban–Rural Income Gap: Empirical Evidence from China. Agriculture 2023, 13, 1950. https://doi.org/10.3390/agriculture13101950.

27. Su, F.; Song, N.; Ma, N.; Sultanaliev, A.; Ma, J.; Xue, B.; Fahad, S. An Assessment of Poverty Alleviation Measures and Sustainable Livelihood Capability of Farm Households in Rural China: A Sustainable Livelihood Approach. Agriculture 2021, 11, 1230. https://doi.org/10.3390/agriculture11121230.

28. Wang, W., Lan, Y., & Wang, X. (2021). Impact of livelihood capital endowment on poverty alleviation of households under rural land consolidation. Land Use Policy, 109, 105608.

29. Jie, F. A. N., Kan, Z. H. O. U., & Jianxiong, W. U. (2020). Typical study on sustainable development in relative poverty areas and policy outlook of China. Bulletin of Chinese Academy of Sciences (Chinese Version), 35(10), 1249-1263.

30. Ji, X.; Wang, K.; Xu, H.; Li, M. Has Digital Financial Inclusion Narrowed the Urban-Rural Income Gap: The Role of Entrepreneurship in China. Sustainability 2021, 13, 8292. https://doi.org/10.3390/su13158292.

31. Chai K-C, Ma X-R, Yang Y, Lu Y-J and Chang K-C (2022) The impact of climate change on population urbanization: Evidence from china. Front. Environ. Sci. 10:945968. doi: 10.3389/fenvs.2022.945968.

32. McCormick, Ted. William Petty: and the ambitions of political arithmetic. Oxford University Press, USA, 2009.

33. Smith, Adam. The wealth of nations [1776]. Vol. 11937. na, 1937.

34. Schultz T W. On human capital investment[J]. Beijing Institute of Economics Press: Beijing, China, 1990.

35. Pigou, Arthur. The economics of welfare. Routledge, 2017.

36. Jiang, Q.; Li, Y.; Si, H. Digital Economy Development and the Urban–Rural Income Gap: Intensifying or Reducing. Land 2022, 11, 1980. https://doi.org/10.3390/land11111980.

37. Xuelong Wang, Lili Zhu, Nana Li, Shunyu Wang, Shuhan Yang, A study of the impact of financial agglomeration on the urban-rural income gap. Financial Engineering and Risk Management (2023) Vol. 6: 92-101. DOI: http://dx.doi.org/10.23977/ferm.2023.061113.

38. Figueredo, A.J., Wolf, P.S.A. Assortative Pairing and Life History Strategy. Hum Nat 20, 317–330 (2009). https://doi.org/10.1007/s12110-009-9068-2.